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THE BEDEL SCORE: SUGGESTING A NEW SCORING SYSTEM TO AVOID NEGATIVE APPENDECTOMY

Cihan Bedel[1*], Mustafa Korkut[1], Fatih Selvi[1], Ökkeş Zortuk[1]
Department of Emergency Medicine, Health Science University, Antalya Training and Research Hospital, Antalya, Turkey

ABSTRACT

Introduction: Scoring systems are still valuable and valid for differential diagnosis of acute appendicitis (AA). Bedel Score is a new diagnostic tool with 7 parameters that can be easily applied. The aim of this study is to determine the diagnostic performance of the Bedel score in AA and compare it with the Alvarado score. **Methods:** Our study consisted of 95 patients as a prospective cohort who were admitted to our emergency department due to abdominal pain and were hospitalized with a preliminary diagnosis of AA. Bedel and Alvarado scores were calculated. The patients were categorized into two groups (positive and negative appendectomy) according to their histopathological diagnosis. **Results:** The study population consisted of 65 (68.4%) male and 30 (31.6%) female patients. The mean age of the patients was 34 (18-87) years. 81 (85.3%) of the patients had histopathologically confirmed AA. Median Alvarado score was significantly higher in patients with positive AA than those with negative AA (7 (range: 3-10) vs. 5 (range 3-7), $p<0.001$, respectively). Median Bedel score of positive AA patients were also significantly higher than those with negative AA (9 (range: 6-10) vs. 5 (range 2-8) $p<0.001$, respectively) In separating acute appendicitis from negative exploration, the threshold of the Alvarado score is 63% sensitivity for ≥7, 85.7% specificity; The Bedel score had 80.2% sensitivity and 92.9% specificity for the threshold value ≥7. **Conclusion:** Bedel score is fast, simple, easy to learn and apply, as well as an effective and practical scoring system with only 7 parameters.

Keywords: Acute appendicitis; Alvarado score; New score; Negative appendectomy.

Corresponding Author:
C. Bedel, MD.
Address: Health Science University Antalya Training and Research Hospital, Kazım Karabekir Street, Murat paşa, Antalya, Turkey.
Phone: +905075641254 ; **Fax:** +902422494487
E-mail: cihanbedel@hotmail.com

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INTRODUCTION

Acute appendicitis (AA) is the most common surgical emergency in patients with abdominal pain admitted to the emergency room, with an estimated lifetime prevalence of 7% [1]. It is mostly seen in adolescents and young adults. Despite advances in imaging technologies in diagnosis and many laboratory examination and scoring systems, it remains difficult to diagnose, as it mimics other pathologies in women and the geriatric population [2,3]. These diagnostic scoring systems aim to increase the diagnostic accuracy of AA and reduce complications such as perforation and sepsis and decrease morbidity and mortality [4]. Although many scoring systems are recommended in this regard, Alvarado score is the best known and best performing score in validation studies, but no scoring system is ideal and the negative appendectomy rate is still high [5].

We developed the Bedel score as a new scoring system by adding the immature granulocyte (IG), which has been used as a new inflammatory marker, to the gender, nausea & vomiting used in the RIPASA, one of the previous scoring systems, and the physical examination findings used in the Alvarado scoring system, and leukocytosis parameters [1-5]. The Bedel score is a new easily applicable diagnostic tool consisting of 7 parameters based on supporting the patient's sex, symptoms and findings with laboratory tests. The primary purpose of this study is to determine the diagnostic

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performance of the Bedel score in AA. Its secondary aim is to compare the results of the Bedel score with the Alvarado score.

METHODS

Our study was designed as a single-centre prospective cohort and was selected among the patients who were admitted to our tertiary emergency department between January and April 2020 due to abdominal pain and were hospitalized with the pre-diagnosis of AA. After the approval of the Antalya Training and Research Hospital ethical committee the consent of all patients was obtained and the data forms were filled by the emergency physicians who first examined the patients. 95 patients who met the inclusion criteria were entitled to participate in the study. Bedel scores that includes 7 parameters and Alvarado scores of these patients were calculated [6].

The Bedel Scoring System

The Bedel scoring system consists of 7 parameters. The first one is the gender parameter and the male gender is scored over 2 points. The two symptoms of the patients were scored as 1 point for the presence of nausea and / or vomiting, and the absence of urinary symptom as 2 points. Sensitivity to the right iliac fossa from the physical examination findings of the patient was 2 points; rebound was scored as 1 point. In addition,> 10,000 / mm^3 leukocyte count and IG percentage > 0.6% are laboratory parameters recorded as 1 point each. The maximum number of points for diagnosis is 10 and the minimum score is 0. (**Table I**)

Study Design

Patients who were planned to be operated and hospitalized with a preliminary diagnosis of AA by general surgery aged 18 and over were included in the study. Patients under the age of 18, those who underwent elective appendectomy, those who were not operated or did not accept hospitalization, patients with incomplete data were taken as exclusion criteria. Complaints (nausea, vomiting, loss of appetite, duration of pain, character of pain), examination findings (presence of tenderness in the right lower quadrant, presence of rebound) and laboratory results (white blood cell (WBC), polymorphonuclear leukocyte percentage (PNL), CRP) of the patients were recorded. The findings suggesting AA in the ultrasonography (US) and abdominal tomography (CT) of the patients were recorded as positive AA [7]. Bedel and Alvarado scores of all patients were calculated and sensitivity in diagnostic performance, specificity, positive predictive value (PPV) and negative predictive value (NPV) were determined. Postoperative histopathology findings were collected and patients were categorized into two groups as positive and negative appendectomy according to histopathological diagnosis. In addition, the correlation of the scores with the imaging findings and histopathological findings were analyzed.

Statistical Analysis

The statistical analysis of all variables was performed by using SPSS version 23.0. The continuous variables were described as standard deviations and means, and categorical variables were described as frequencies and percentages (%). In the comparison of the positive and negative appendectomy groups in terms of parameters, student t test was used for variables with normal distribution, and Mann Whitney U test was used for variables without normal distribution. The receiver operating characteristic (ROC) analysis was performed to determine the success of Alvarado and Bedel scoring systems in diagnosing AA. Sensitivity, specificity, PPV and NPV values of scores were calculated and its diagnostic performance was evaluated. Histopathological confirmation was accepted as the gold standard. An adjusted rate ratio (OR) and 95% confidence interval (CI) were also calculated for each independent variable, and p value below 0.05 was considered statistically significant.

RESULTS

95 patients who met the inclusion criteria were included in our study. 81 (85.3%) of the patients had histopathologically confirmed AA. The appendectomy of 14 (14.7%) patients was negative and 3 (3.2%) of these patients had tumors, and 2 (2.1%) of lymphoid hyperplasia, unusual histopathological findings and appendix vermiformis were detected. The median Alvarado score of the patients was 7 (range: 3-10); the median Bedel score was 8 (range: 2-10) (**Table II**).

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Table I: Bedel scoring system

Variable	Value
Gender	
Male	2
Symptoms	
Nausea /Vomiting	1
Absence of urinary system complaints	2
Signs	
Sensitivity on lower right quadrant	2
Rebound tenderness in right iliac fossa	1
Laboratory findings	
WBC >10.000/mm3	1
IG>0.6%	1
Total points	10

WBC: White blood cell; IG: Immature granulocytes

Table II: Baseline characteristics of studied patients

Variables	Values (n=95)
Age (years)	
Median (IQR)	34 (21-69)
Gender, n (%)	
Male	65 (68.4)
Female	30 (31.6)
Appendectomy findings for AA	
Positive	81 (85.3)
Negative	14 (14.7)
Histopathological findings, n (%)	
Acute appendicitis	73 (76.8)
Complicated appendicitis	8 (8.4)
Lymphoid hyperplasia	2 (2.1)
Unusual histopathological findings	2 (2.1)
Appendix vermiformis	2(2.1)
Tumors	3 (3.2)
Others	5 (5.3)
Clinical findings, n (%)	
Sensitivity on lower right quadrant	94 (98.9)
Defense-rigidity	81 (85.3)
Rebound	79 (83.2)
Migration of pain to the right lower quadrant	22 (23.2)
Loss of appetite	59 (62.1)
Fever (>37.3°)	7 (7.4)
Nausea-Vomiting	69 (72.6)
Urinary system complaint	10 (10.5)
Time pain started	
<48	63 (66.3)
≥48	32 (33.7)
Laboratory findings	
WBC count ($\times 10^3/mm^3$)	13.62±4.31
Polymorphonuclear leukocytes (%)	73.66±11.81
Immature granulocytes (%)	0.63±0.4
C-reactive protein (mg/dL)	22.7 (1-277)
Scores, median (range)	
Bedel	8 (2-10)
Alvarado	7 (3-10)
Bedel score (no of cases)	
<5	6 (6.3)
5-7	23(24.2)
8-10	66 (69.5)

AA: Acute appendicitis; WBC: white blood cell.

There was no significant difference between the positive and negative AA groups when evaluated according to their median age (p=0.067). According to gender distribution, positive AA was higher in males and negative appendectomy was higher in females (p=0.007). While US could not differentiate positive AA from negative significantly, CT had significantly higher AA detection (p=0.175 vs. p<0.001, respectively). Mean of patients with positive AA according to clinical findings as defense-rigidity, rebound and nausea percentage were significantly higher than those with negative AA (p=0.001; p<0.001; p=0.019, respectively), but urinary system complaints were significantly lower (p<0.001). In addition, in the positive AA group, mean WBC, IG and PNL values were significantly higher than those with negative AA (p=0.001; p <0.001; p<0.001, respectively). The median Alvarado score was 7 (range: 3-10) in AA patients, and the median Alvarado score was 5 (range 3-7) in patients with negative AA. Median Alvarado score was significantly higher in patients with positive AA (p<0.001). The median Bedel score was 9 (range: 6-10) in AA patients and the median Bedel score was 5 (range 2-8) in patients with negative AA. Median Bedel score was also significantly higher in patients with positive AA (p<0.001) (**Table III**).

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Table III: Comparing the baseline characteristics as well as acute appendicitis scores between cases with acute and negative appendectomy findings

Variables	Appendectomy findings		p value
	Negative (n=14)	Positive (n=81)	
Age (years)			
Median (range)	44 (21-87)	33 (18-80)	0.067
Gender, n (%)			
Male	5 (35.7)	60 (74.1)	0.007
Female	9 (64.3)	21 (25.9)	
US findings, n (%)			
Negative	4 (28.6)	22 (27.2)	0.175
Positive	6 (42.9)	45 (55.6)	
CT scan findings, n (%)			
Negative	2 (14.3)	1 (1.2)	<0.001
Positive	9 (64.3)	49(60.5)	
Clinical findings, n (%)			
Sensitivity on lower right quadrant	14 (100)	80 (98.8)	0.853
Defense-rigidity	7 (50)	74 (91.4)	0.001
Rebound	5 (35.7)	74 (91.4)	<0.001
Migration of pain to the right lower quadrant	0 (0)	22(27.2)	0.035
Loss of appetite	9 (64.3)	50 (61.7)	0.553
Fever (>37.3°)	2 (14.3)	5 (6.2)	0.274
Nausea-Vomiting	6 (42.9)	63 (77.8)	0.019
Urinary system complaint	9 (64.3)	1 (1.2)	<0.001
Time pain started			
<48	10 (71.4)	53 (65.4)	0.767
≥48	4 (28.6)	28 (34.6)	
Laboratory findings			
WBC count ($\times 10^3/mm^3$)	10.41 ± 2.63	14.17 ± 4.31	0.001
Polymorphonuclear leukocytes (%)	63.80 ± 7.29	75.36 ± 11.63	<0.001
Immature granulocytes	0.56 ± 0.38	0.64 ± 0.40	<0.001
C-reactive protein (mg/dL)	29.65 (3-171)	21 (1-277)	0.176
Scores, median (range)			
Bedel	5 (2-8)	9 (6-10)	<0.001
Alvarado	5 (3-7)	7 (3-10)	<0.001

US: Ultrasonography; CT: Computed tomography

Alvarado and Bedel scores effectiveness' in detecting AA was calculated by drawing the ROC curve. Alvarado score revealed that the area under the curve (AUC) was significant in distinguishing positive AA from negative appendectomy (AUC: 0.902, 95% CI: 0.822-0.982; p<0.001) (Fig. 1). In distinguishing acute appendicitis from negative exploration, for the threshold value of Alvarado score ≥7 has 63% sensitivity, 85.7% specificity, 75.31% PPV, and 35.71% NPV (**Table IV**). The Bedel score also revealed that AUC was significant in distinguishing positive AA from negative appendectomy (AUC: 0.975, 95% CI: 0.929-1.000; p<0.001), respectively) (Fig. 1). In distinguishing acute appendicitis from negative exploration, for the threshold value of Bedel score ≥7 has 80.2% sensitivity, 92.9% specificity, 96.3% PPV, and 82.88% NPV.

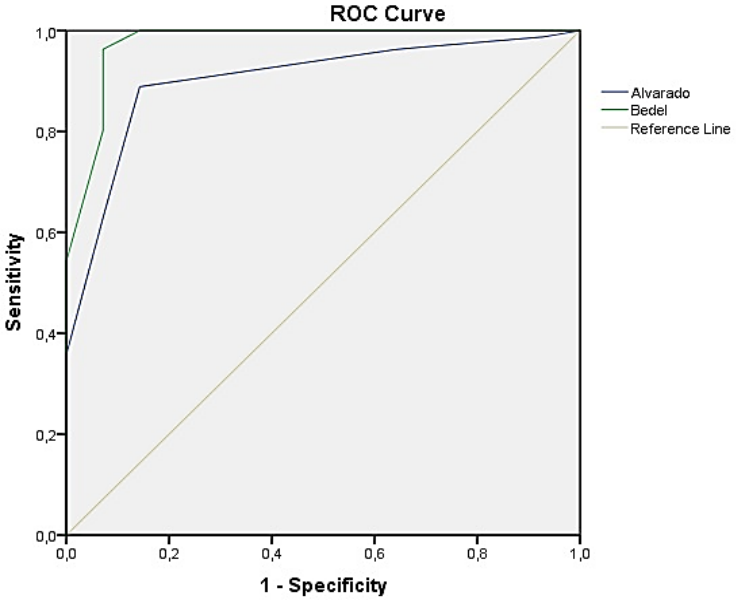

Fig. 1. Receiver operating characteristics curve demonstrating the predictive values of the Bedel scoring systems.

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Table IV: Diagnostic performance of Bedel and Alvarado scores

	Bedel	Alvarado
The area under the ROC curve	0.975	0.902
95% confidence interval	0.929-1.000	0.822-0.982
Diagnostic accuracy	86.5	74
p value	<0.001	<0.001
Cutoff point	≥7	≥7
Sensitivity	80.2	63
Specificity	92.9	85.7
Positive predictive value	96.3	75.31
Negative predictive value	82.88	35.71

DISCUSSION

Diagnosing AA still poses a challenge, and delaying the surgical operation increases the complication rate, leading to increased mortality and morbidity [8]. In addition to clinical evaluation in studies to increase the accuracy of the diagnosis of AA, its diagnostic effectiveness has been proven in modern imaging methods with various clinical signs and symptoms [9,10]. Scoring systems that developed to increase both sensitivity and specificity of the diagnosis of AA still remain important with its cheap, non-invasive and ease of use [3]. In this study, we showed that the cost of AA can be a fast, simple, easy to learn and apply diagnostic method that does not require extra expense since it contains the seven clinically important parameters. The Bedel score generally has high sensitivity and sensitivity and can be considered as an ideal clinical scoring system for the diagnosis of AA.

Bedel score is a new, easy to apply and effective scoring system that includes clinical symptoms, findings, and simple hemogram parameters. Unlike Alvarado and other scoring systems, it contains fewer parameters. Other parameters except the IG parameter are well known from previous studies. Like the Alvarado score, leukocytosis was taken as 10,000 / mm^3 in the diagnosis of acute appendicitis in the Bedel score. In previous studies, it is known that leukocystosis can distinguish AA with high sensitivity and specific [11]. However, although more than 75% of PNL is a distinction for AA, its low sensitivity and specificity have been demonstrated in studies [12]. Therefore, in our study, instead of this parameter we added the IG parameter, which is a fast marker of rapid applicability, easy to measure from simple hemogram testing and a rapid marker of inflammation, to our score [13]. We also included gender in our scoring system, which is a decisive parameter in negative appendectomy, which was also included in previous scoring systems [14]. By including IG, which has not been included in any scoring system before, we have developed a fast and effective scoring system. Bedel score can be easily used by clinicians with few parameters and high sensitivity and specificity. We think that the application of this score can reduce negative AA when appendicitis is suspected and minimize the need for imaging costs in the overall management of these patients.

Unlike the Alvarado score, fever and pain migration is not used as a parameter in the Bedel score due to the limited diagnostic significance shown in other studies.15,16 In our study, the fact that the presence of fever was only in 5 positive AA patients (6.2%) and the presence of pain migration was only in 22 positive AA patients (27.2%) supported our hypothesis that these were not a valuable indicator for AA.

In this study, the threshold value of the Bedel score in distinguishing AA from negative exploration was 80.2% sensitivity, 92.9% specificity, 96.3% PPV and 82.88% NPV for ≥7. In a study by Chong et al. for the RIPASA score of 7.5, the optimal threshold limit was found to have higher sensitivity and specificity 98.02% (95% CI 93.03% - 99.76%) and 81.32% (95% CI 71.78% - 88.72%). Again in this study, for the score of Alvarado > 7 sensitivity was detected as 68.32 and the specifity was detected as 87.91% specificity [17]. In another study, it was stated that RIPASA score results showed 94.5% sensitivity, 88.0% specificity, 97.2% PPV, 78.5% NPV and 93.38% diagnostic accuracy [18]. However, if the Bedel score consisting of only 7 parameters is compared with the RIPASA score, it requires less parameters. Erdem et al. found that the sensitivity and the specifity of the Alvarado scoring system was calculated as 82% and 75%, respectively, and the sensitivity and specificity of the RIPASA scoring system was calculated as 100% and 28%, respectively. The sensitivity and specificity of the Ohmann score was calculated as 96% and 42% respectively, and the sensitivity and specificity of the Eskelinen scoring system as 100% and 44%, respectively. They also stated that the RIPASA scoring system was less accurate due to high negative appendectomy rates in this study [8].

The overall negative appendectomy rate of our study is 14.7, which is higher in women compared to men (30% vs.7.6%). Many surgeons advocate early surgical intervention to prevent complications in cases they suspect, although this rate varies between 20-40%, the generally accepted rate is between 15-20% [9,19,20]. Tumor and lymphoid hyperplasia was the most common leading cause of negative appendectomy. In our study, both the Alvarado and

Bedel scores could not distinguish these false positive diagnoses. Although imaging methods come to the forward in preventing false positive diagnoses, operator-dependent CT may be much more useful in reducing the rate of negative appendectomy [21,22]. Considering the risks and disadvantages of CT, such as cost, radiation exposure and complications related to contrast, we can think that effective use of the Bedel score by clinicians can reduce CT use. Bedel score can be easily used by physicians as a score predicting negative AA.

Many scoring systems have been developed for the diagnosis of AA and the detection of negative AA. RIPASA, which is one of them, is one of the prominent scoring [8, 17]. Since the number of parameters in our study is less than RIPASA, we think that it can stand out with its fast computability. There is a need for its use in AA with studies that can only be compared with the Bedel score.

STUDY LIMITATIONS

This research had some limitations. First, the sample size was low. Secondly, no comparison was made with other scoring systems other than the Alvarado score. Another limitation was both radiological and pathological evaluations were made by different physicians, which may lead to differences in clinical evaluation.

CONCLUSION

The diagnosis of AA is still based on physical examination, clinical and laboratory data. Bedel score is fast, simple, easy to learn and apply, as well as an effective and practical scoring system with only 7 parameters. The Bedel score can predict negative appendectomy better than the Alvarado score.

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